THE UNIVERSITY OF BRITISH COLUMBIA
School of Kinesiology

**KIN 501 Computational methods for data acquisition and signal processing in Kinesiology**

## ACKNOWLEDGEMENT

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xwməθkwəy̓əm (Musqueam) people. The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on in their culture, history, and traditions from one generation to the next on this site.

## COURSE INFORMATION

| Course Title | Course Code Number | Credit Value |
| --- | --- | --- |
| Computational methods for data acquisition and signal processing in Kinesiology | KIN 501 | 3 |

## COURSE DESCRIPTION

The focus of this course is to provide graduate students with the practical experience necessary for the acquisition and processing of data related to human movements. This course will cover modern approaches and techniques commonly used for wearable sensing and laboratory research applicable to diverse disciplines related to Kinesiology, including biomechanics, physiology, neuroscience, psychology, and motor learning. These approaches and techniques include (but are not limited to) sampling theory, acquisition of analog and digital data with microcontrollers for embedded applications, wearable and laboratory-grade instruments, synchronization of data from multiple sources, analog and digital filters as well as common data analysis methods. It is assumed that students have an undergraduate background in Kinesiology or related field, including basic linear algebra and computer skills. Emphasis is placed on hands-on laboratory skills, presentation skills and on the computer methods underlying the development of a research project.

## COURSE PRE-REQUISITES

None. Students should have an undergraduate degree in Kinesiology or related field. Basic linear algebra and computer skills acquired in neuromechanical science courses in Kinesiology (or similar) are expected.

## CONTACTS

| Course Instructor(s) | Contact Details | Office Location | Office Hours |
| --- | --- | --- | --- |
| Jean-Sébastien Blouin | **Phone:** 604-827-3372 | Lower Mall Research Station (room 354) | |
| | **Email:** jsblouin@mail.ubc.ca | | |

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## LEARNING OBJECTIVES

By the end of this course, students will be able to:
1. Understand and apply fundamental theoretical concepts for the acquisition and analysis of data related to human movement.
2. Use hardware and software computational tools and approaches to acquire and process data associated with human movements.
3. Formalise and present conceptual research methodology ideas
4. Understand, describe and present computational & methodological approaches and results on data acquisition/signal processing topics related to human movements.
5. Evaluate the application of data acquisition and processing approaches to specific situations and provide feedback to peers.
6. Develop and perform a research project related to the students' research interest for an in-depth learning of specific computational topics discussed in class.

## LEARNING ACTIVITIES

Students are required to perform weekly laboratory activities and/or presentations on topics discussed in class. In addition, they need to prepare for the material to be discussed in the roundtable discussions through proposed readings and collaborate with their peers.

## COURSE STRUCTURE

This course will be delivered synchronously on the UBC Point Grey campus. An online component to the course through the online learning systems Canvas will provide course descriptions, syllabus, readings, assessment feedback, and other course materials.

## COURSE EVALUATION

A. Weekly or bi-weekly presentations: 30%

Learning objectives 1, 2, 3, 4.

Students will lead a 4-minute presentation on the data acquisition/processing approaches and techniques learned during the preceding week. Students are encouraged to use LibreOffice, GSuite or Powerpoint. During the term, students are encouraged to use at least once a less familiar software for data collection and analysis (Spike2, Matlab, Python, R, Julia, Arduino IDE or LabVIEW). The aim of using two distinct software environments is to provide students with experience collecting and analyzing data in their lab preferred environments. Note that for most research laboratories in Kinesiology, data acquisition and analysis is performed using distinct software.

Grading criteria:

- Conceptual understanding of the procedures
- Quality and clarity of figures for data visualization & illustration of the main concepts.
- Content and organization of the presentation.
- Presentation skills and answers to questions from the audience.

B. Leading weekly or bi-weekly seminars: 20%

Learning objectives 1, 4.

Students will lead class 30-45 min discussions at least once during the term. Depending on class enrollment, these presentations may be performed in teams.

Grading criteria:

- Clearly presenting and highlighting 3 to 5 main theoretical concepts in the assigned material (the use of creative figures and videos is encouraged)
- Quality and clarity of figures for illustration of the main theoretical concepts.
- Content and organization of the presentation.
- Presentation skills and answers to questions from the audience
- Capacity to lead a discussion with a focus on potential limitations/issues related to the readings

C. Computational Research Methods Project - Proposal and Presentation: 30%

Learning objectives 1, 2, 3, 4, 5, 6.

Proposal (15%): Due on Week 6. Students will submit a proposal for their proposed computational research methods project. Feedback will be provided to students regarding expectations for final project.

Grading criteria:

- Description of the main data acquisition and/or signal processing issue(s) that will be addressed
- Description and justification for the proposed computational methods and approaches and how these will address the identified issue(s).

Presentation (15%). Date to be determined. A 15-minute oral presentation of their computational research methods project. Students are encouraged to use LibreOffice, GSuite or Powerpoint. Students will present their project with a major emphasis on the data acquisition requirements and/or signal processing approaches necessary for interpreting the data.

Grading criteria:

- Relate the chosen data acquisition or analysis procedures to theoretical concepts reviewed in class
- Critically justify and evaluate the chosen computational approaches
- Quality and clarity of figures for data visualization & illustration.
- Content and organization of the presentation.
- Presentation skills and answers to questions from the audience.

D. Peer-evaluation: 10%

Learning objective 5.

Students will collaborate with and provide feedback to their peers on the computational code they generated for the weekly activities. An emphasis will be placed on good code writing practices, including clear, readable, and reusable code that is well-commented. They will also learn to use an online platform for code sharing and collaboration.

Grading criteria:

- Use online platform for code sharing
- Identify the main strength or the reviewed code.
- Identify one or two aspects of the code that are weak, ineffective, or incorrect.
- Make a recommendation for one of the code aspects that is weaker, ineffective or incorrect.

E. Class participation: 10%

Learning objectives 1, 5.

Active class participation is required for the good functioning of the course. Students will be graded based on their preparation of the assigned material and participation to in-class roundtable discussions.

Grading criteria:

- Preparation for the course material prior to seminars
- Active engagement in the class discussions

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This course is centered around the students' interests and human movement data acquisition/processing needs. Consequently, students will be able to use the equipment in their research lab as well as microcontrollers, wearable or laboratory-grade instrumentation available in the School of Kinesiology Learning Centre for the hands-on component. Although we will cover the theory underlying data acquisition and analysis, we will focus on the applications of key data acquisition and analysis concepts critical for applications involving human movements.

## LEARNING MATERIALS (READINGS)

Readings will consist of book chapters and original research articles from peer-reviewed journals.

**Each week, students will be assigned a set of readings.** These readings are intended to provide a background overview of the themes and concepts and must be read in preparation for the seminars. Students will facilitate a roundtable discussion and presentation of the topics covered in the assigned readings.

**For week 1**, students must bring to class a paper that uses a signal processing technique or describe a data-related problem they intend to learn in this course.

Sample list of recommended readings (more may be added throughout the course as appropriate):

- Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing http://www.dspguide.com/pdfbook.htm
- Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Elsevier 2007. 308 pages https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos
- Wallisch P, Lusignan M, Benayoun M, Baker TI, Disckey AS, Hatsopoulos NG. MatLab for Neuroscientists. An introduction to scientific computing in Matlab. Elsevier. 2009. 384 pages
- Gribble P. Scientific Computing with MATLAB (2016). https://openlibra.com/en/book/download/scientifc-computing-with-matlab
- LabVIEW Manuals and Help Guides
  http://www.ni.com/pdf/manuals/320999e.pdf
- Matlab Manuals and Help Guides
  http://www.mathworks.com/help/matlab/index.html
  http://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf
  http://www.mathworks.com/help/pdf_doc/matlab/matlab_prog.pdf
- Python Books, Help Guides and Tutorials
  https://wiki.python.org/moin/BeginnersGuide
  https://greenteapress.com/wp/think-python-2e/
  https://greenteapress.com/wp/think-dsp/
- Bendat JS, Piersol AG. Random data analysis and measurement procedures (3rd Ed). Wiley. 2000. 594 pages
- Siegmund GP. The reflex response of human neck muscles to whiplash-like perturbations.

Doctoral thesis, The University of British Columbia. 2001
- Teasdale N, Bard C, Fleury M, Young DE, Proteau L. Determining Movement Onsets from Temporal Series Journal of Motor Behavior. 1993; 25(2):97-106. DOI:10.1080/00222895.1993.9941644
- Van Boxtel GJ, Geraats LH, Van den Berg-Lenssen MM, Brunia CH. Detection of EMG onset in ERP research. Psychophysiology. 1993 Jul;30(4):405-412.
- Hodges PW, Bui BH. A comparison of computer-based methods for the determination of onset of muscle contraction using electromyography. Electroencephalogr Clin Neurophysiol. 1996 Dec;101(6):511-519.
- Gescheider GA. Psychophysics: The Fundamentals. Taylor & Francis. 1997. 435 pages
- Halliday DM and Rosenberg JR. Time and frequency domain analysis of spike train and time series data (Chap 18). In Modern Techniques in Neuroscience Research. (Eds: Windhorst U & Johanson H). Springer. 1999.
- Winter DA. Biomechanics and Motor Control of Human Movement. Wiley. 2009. 384 pages
- Merfeld DM. Signal detection theory and vestibular thresholds: I. Basic theory and practical considerations. Exp Brain Res. 2011 210(3-4):389-405. doi: 10.1007/s00221-011-2557-7.
- Osborne TM, Lakie M. A novel planar tracking technology for physiological image analysis. J Neurosci Methods. 2011. 202(1):53-9. doi: 10.1016/j.jneumeth.2011.08.041.
- Staude G, Wolf W (1999) Objective motor response onset detection in surface myoelectric signals. Med Eng Phys 21:449-467.
- Staude GH (2001) Precise onset detection of human motor responses using a whitening filter and the log-likelihood-ratio test. IEEE Trans Biomed Eng 48:1292-1305.

## SCHEDULE OF TOPICS

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| **Week 1** | Course Introduction<br>• Brief introduction. Presentation of computer software relevant for data analysis and presentation as well code sharing.<br>• Presentation of guidelines for good code writing practices.<br>• Students present a paper that uses a signal processing technique or describe a data-related problem they intend to learn from this course. |
| **Week 2** | Signal Processing overview and Introduction to Matlab, Python, R & LabVIEW<br>Readings:<br>• Gribble P. Scientific Computing with MATLAB (2016). Chap 1 & 2.<br>• Wallisch P et al. Matlab for Neuroscientists. An introduction to scientific computing in Matlab. Chap 2.<br>• https://www.youtube.com/watch?v=7bnVx34yQf4<br>• https://www.mathworks.com/learn/tutorials/matlab-onramp.html<br>• http://www.ni.com/getting-started/labview-basics/ |
| **Week 3** | Sampling a continuous time signal and Introduction to analog & digital signals using wearable or laboratory-grade instruments<br>Readings:<br>• Van Drongelen W. Signal Processing for Neuroscientists. An introduction |

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| | to the analysis of physiological signals. Chap 1 & 2 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos)<br>• Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 3 (pp 35-48) & 4.<br>Matlab & Arduino<br>• https://www.youtube.com/c/ArduinoRoboticsLabVIEWSolidworks/search?query=matlab%20arduino<br>• https://www.youtube.com/watch?v=8NQ1h0gGgX8<br>• https://www.youtube.com/watch?v=nOz3uTi20Jo<br>LabVIEW<br>• http://www.ni.com/white-paper/52648/en/<br>• http://www.ni.com/product-documentation/2835/en/ |
| **Week 4** | Preliminary findings, Tutorial & Discussions on Sampling a continuous time signal and Introduction to analog & digital signals. |
| **Week 5** | Synchronization of data from different sources using wearable and/or laboratory-grade instruments<br>Readings:<br>• Osborne TM, Lakie M. A novel planar tracking technology for physiological image analysis. J Neurosci Methods. 2011. 202(1):53-9. doi: 10.1016/j.jneumeth.2011.08.041.<br>• Abraham L, Kalakanis D. Synchronization Of Video Kinematic And Analog Biomechanical Data Using The Motion Analysis System. International Symposium on Biomechanics in Sports (1993)<br>• Wu J, Sun L, Jafari R. A wearable system for recognizing American sign language in real-time using IMU and surface EMG sensors. IEEE Journal of Biomedical and Health Informatics. Vol 20:5, 2016<br>• http://www.ni.com/product-documentation/4322/en/<br>• http://www.ni.com/tutorial/11549/en/<br>• https://www.ni.com/en-ca/support/documentation/supplemental/10/synchronization-explained.html |
| **Week 6** | Data analysis, noise & signal averaging<br>Readings:<br>• Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 3 & 4<br>• Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 2 & 4. |

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| **Week 7** | Continuous, discrete and Fast Fourier Transform. Brief overview of correlation in the time and frequency domains.<br>Readings (recommended to read in order):<br>• Wallisch P et al. Matlab for Neuroscientists. An introduction to scientific computing in Matlab. Chap 7 & 10.<br>• Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 5-6-8-9-10 & 12.<br>• Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 5, 6, 7 & 8 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos) |
| **Week 8** | Preliminary findings, Tutorial & Discussions on Continuous, discrete and Fast Fourier Transform |
| **Week 9** | Introduction to filters & filter analysis: The RC circuit<br>Readings:<br>• Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 10, 11, 12 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos)<br>• Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 3 (pp 48-58) |
| **Week 10** | Introduction to filters & filter analysis: Digital filters<br>Readings:<br>• Van Drongelen W. Signal Processing for Neuroscientists. An introduction to the analysis of physiological signals. Chap 13 (see online lectures: https://www.youtube.com/channel/UC8owx2vNE7XVrjMOCUgZkAA/videos)<br>• Smith, SW. The Scientist and Engineer's Guide to Digital Signal Processing. Chap 14, 15, 16, 19, 20 & 21 (chapter 17 if interested). |
| **Week 11** | Preliminary findings, Tutorial & Discussions on Introduction to filters & filter analysis: Digital filters |
| **Week 12** | Research Project |
| **Week 13** | Research Project |
| **Week 14** | Research Project Presentations |

## ONLINE COMMUNICATIONS

In this course, students are expected to communicate in a respectful and professional manner. Instructors do not allow, for example, discriminatory or offensive language and hate speech. It may be helpful to review UBC's Distance Learning Communication Online: Netiquette web page.

## GRADING SYSTEM – FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

| PERCENTAGE (%) | LETTER GRADE |
|---|---|
| 90-100 | A+ |
| 85-89 | A |
| 80-84 | A- |
| 76-79 | B+ |
| 72-75 | B |
| 68-71 | B- |
| 64-67 | C+ |
| 60-63 | C |
| 0-59 | F (Fail) |

A minimum mark of 68% must be obtained in all courses taken by a student enrolled in a doctoral program.

The minimum passing grade in any course taken by a student enrolled in a master's program is 60%. However, only 6 credits of courses with grades in the C to C+ range (60-67%) may be counted towards a master's program. For all other courses, a minimum of 68% must be obtained.

Academic progress and grading practices are outlined on G+PS policies and procedures website.

## UBC POLICY ON PLAGIARISM

All students should be aware of and follow UBC's Guidelines regarding Plagiarism. Please read and familiarize yourself with these guidelines. These policies are taken seriously by course instructors and program administrators.

## ETHICAL AND PROFESSIONAL CONDUCT

Students are expected to adhere to standards of professional practice and ethics in their interactions with faculty, peers, and the public.

## UNIVERSITY POLICIES

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available on the UBC Senate website and Discrimination policy. For student accommodations, please see Access and Diversity.

## ACADEMIC INTEGRITY

Students are expected to follow UBC policies for academic integrity and academic misconduct, which includes practices around plagiarism, referencing and citation, and copyright. For more see, UBC's Learning Commons Academic Integrity resources, Academic Integrity Hub and graduate student misconduct in Graduate and Postdoctoral Studies.

## POLICY ON TEXT-MATCHING SOFTWARE

UBC subscribes to Turnitin, an online system that compares written material with the Web and with other material submitted to its database. Faculty, staff and students can upload submissions and check for duplication of material in other sources and possible plagiarism.

## ACCESSIBILITY

If you have any challenges accessing materials that will impact your success in this course, UBC's Centre for Accessibility can support your needs by providing appropriate accommodations to support you.

- Web: UBC's Centre for Accessibility website
- Email: accessibility@ubc.ca

## RESOURCES

Students requiring counselling services may contact UBC counselling services